**ALA 6.1 Marker-Assisted Backcrossing (MABC)**

**Prerequisites**

Understanding of:

1. Backcross (BC) breeding
2. Main application of molecular markers for BC breeding
3. Factors influencing the efficiency of BC breeding

Crop Improvement course

**Purpose**

Expose learners to a real-life scenario of MABC, where the goal is not only conversion of a given inbred line by MABC, but also to maintain the overall yield gain in a breeding program.

**Background**

MABC is an established and successful application of molecular markers in plant breeding. When applied to plant breeding programs, the problem is that “time is not standing still” while one or few genes are introduced by MABC into an existing elite line. During the time of line conversion, novel and superior lines are developed. In other words, a MABC converted line may be outdated, when it becomes available, relative to the latest elite inbred lines developed in breeding programs of competitors. Thus, the challenge is how to best introduce gene(s) of interest into the most elite germplasm when given limited (financial) resources.

**Tasks**

You are an employee in a breeding company. Your job is to integrate a new transgene for a disease resistance gene (single dominant gene) into the elite germplasm of soybean, and to develop a resistant cultivar within 5-7 years that has a 2% genetic gain per year. The line containing the transgene is a soybean line that lacks the other desirable agronomical traits. If you are 1 year late relative to the competition, the company will have 10k units of sales lost in the first year, 50k units of sales lost in the second year, and 10k units of sales lost in the third year. If you are 2 years late, there will be 10k units of sales lost in the first year, 100k units of sales lost in the second year, 500k units of sales lost in the third year, and 100k units of sales lost in the fourth year.

Current Program: Three generations per year are possible. Only one is grown in the target environment, while two are grown in winter nurseries, which are not related to the target environment (details are given in supplementary cost sheet).

Year 1,

Home environment, crossing nursery – 100 crosses with 12 F1 seed per successful pollination.

Winter nursery 1 – self F1 plants –> 200 seed per plant. Harvest only 50 crosses, because yield evaluations will indicate that ~ ½ of crosses were with lines that are being dropped from the program.

Winter nursery 2 – self 50 x 200 F2 plants -> 10,000 F2:3 lines, each consisting of ~ 200 seeds

Year 2,

Adapted environment. Initial field evaluation of 10,000 F2:3 lines. Grow each F2:3 line in a two row yield plot consisting of 100 seeds (50 per row). Plant 50 remnant seed for advance to F2:4 lines.

Winter nursery 1. Plant 1000 F2:4 lines based on visual phenotypes, but only harvest 500 F2:5 lines based on results of yield tests.

Winter nursery 2. Plant 500 F2:5 lines for advance to F2:6 lines

Year 3,

Adapted environments. Regional yield test. 100 F2:6 lines evaluated at 10 locations. One of the locations is a disease nursery. Plant remnant seed for advance to F2:7 lines

Winter nursery 1. Plant 100 F2:7 lines for generation advance to F2:8 lines but harvest no more than 40 lines based on results of regional yield and disease nursery.

Winter nursery 2. Plant 40 F2:8 lines for advance to F2:9 lines

Year 4,

Adapted environments. Wide area yield test. 40 F2:9 lines evaluated at 25 locations. One is a special disease nursery. Advance seed to F2:10 .

Winter nursery 1. Plant 40 F2:10 lines for generation advance to F2:11 lines but harvest no more than 20 lines based on results of regional yield and disease nursery.

Winter nursery 2. Plant 20 F2:11 lines for advance to F2:12 lines and recycle 20 lines into the breeding nursery.

Year 5,

Adapted environments. Wide area yield test. 20 F2:12 lines evaluated at 30 locations. One is a special disease nursery.

Winter nursery 1. No resources needed.

Winter nursery 2. Send 5 selected F2:12 lines to parent seed for registration and increase for use in strip trials.

Year 6

Adapted environments. Pre-commercial Strip trials. 5 F2:12 cultivars evaluated at 100 locations.

Winter nursery 1. No resources needed.

Winter nursery 2. 1 selected and registered F2:12 line is increased by parent seed group for use in strip trials.

Adapted environments. Pre-commercial Strip trials. 1 cultivar evaluated in as a pre-release commercial cultivar at 100 locations. Parent seed sends 100 units to the production department for increase to 50K units for use in 1st year sales in Year 8.

**How can you improve the current breeding program using:**

1. Molecular markers for foreground and background selection
   1. How many Backcrossing generations will you need?
   2. Assume that you will use only two flanking markers and answer the following question
      1. What marker technology will you use? Explain your choice
      2. What is the ideal population size for each backcross generation? **Note: You can use popmin program to determine this (**[**http://fhospital.free.fr/fred/work/programs/popmin/**](http://fhospital.free.fr/fred/work/programs/popmin/)**)**
      3. **Ta**In which seasons will you use markers?
      4. How much will the marker analysis cost in the program

NOTE: Include III and IV on your cost sheet

* 1. Would you include more markers in the background? Is it cost effective? Assume you use a fixed number of markers for the background.

1. Assume you are able to develop DH lines in soybean and that developing DH lines in soybean and corn cost the same.
   1. How would you use DH technologies to improve your programs?
   2. In which step of the program would you use it
   3. How much will it cost you (Inquire information from the DH facility at ISU)

Based on the previous analysis, is it cost effective to use marker for selection? DH lines? Or both.

Remember that your maximum budget for this program is $1,000,000.

**Your report should include the breeding strategies as follows:**

* **Breeding scheme**
  + **Explain your choices for number of lines, number of individuals genotyped , etc.**
* **Budget**

**In addition you have to turn in a file with the cost spreadsheet and a maximum 2 pages summary of your breeding scheme including justification of your choices.**

**Tentative answers** (can differ, based on context / assumptions made)